

Statement aangaande de ketenanalyse 2022

Er is in 2021 gekozen om een ketenanalyse te maken van de systeemwanden omdat:

- dit de kern en oorsprong is van de organisatie;
- Verwol de wanden zelf produceert;
- er het meeste grip is op een verduurzamingsslag in deze productgroep.

De meest logische keuze zou zijn om te gaan voor een ketenanalyse gespecificeerd op de glazen systeemwanden omdat deze het beste herbruikbaar zijn (door het ontbreken van isolatiemateriaal) en het meeste toegepast worden. Echter, Jort Lieman had net een module afgerond van zijn opleiding Sustainable Management, waarin hij in een eindopdracht de CO₂-uitstoot van nieuwe wanden vergeleek met second life wanden inclusief het recyclingproces.

Een nieuwe ketenanalyse voor glazen systeemwanden zou inhoudelijk weinig toevoegen. Daarom is er gekozen voor een ketenanalyse op de dichte systeemwanden waarin 2 types van de V100 serie met elkaar zijn vergeleken. In de praktijk blijkt dit vergelijk echter weinig toe te voegen omdat verreweg de meeste impact gemaakt kan worden door wanden in hergebruik vorm in te zetten. Bovendien komen de V100 wanden uit deze ketenanalyse niet zo vaak voor.

Om die reden is er voor gekozen om de eindopdracht uit de opleiding van Jort Lieman te gebruiken als leidraad in de ketenanalyse. Te meer omdat de conclusies uit deze opdracht ook een aanleiding zijn voor gesprekken met architecten (zie hoofdstuk 5.3 uit het CO₂-managementplan). Het belangrijkste hoofdstuk uit de eindopdracht wordt gepubliceerd op de website van SKAO en Verwol. Het betreft hoofdstuk 5.4.1 (pagina 17) t/m 5.4.1.3 (pagina 19). De volledige eindopdracht wordt ter info en onderbouwing op de volgende pagina's gedeeld.

Met dit hoofdstuk, waarin de CO₂-reductie van het hergebruik van systeemwanden wordt berekend, kunnen wij het meeste impact maken in de keten. Bovendien is het praktisch uitvoerbaar en levensvatbaar voor Verwol.

Om een groei in het aantal Returnity projecten te kunnen realiseren moet we in de toekomst meer systeemwanden kunnen 'minen'. Daarom hebben we recentelijk besloten om bij wandenoffertes standaard een passage op te nemen waarin we aangeven dat nieuwe wanden retour genomen worden door Verwol. Zie hiervoor het document 'returnity programma uitleg' in de map bewijslast – Returnity – 2022'.



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Course:	MC4612 - Closed loop supply chains
Assignment:	Research paper

Closed Loop Supply Chains at Verwol.

*A swift introduction that went awry by ignoring
human factors and a lack of determination*

1 Abstract

In 2018, the idea arose to close the loops and reuse wall partitions and doors. Immediately afterwards, the preparation started, and in 2019 the circularly designed Returnity program emerged. Shortly after the implementation the first Returnity clients came along but the progress did not continue very well. While there was no internal criticism of the program and no opposition was expressed, in practice it was business as usual and nothing really changed.

In this research paper I reflect on the introduction of the closed loop supply chain management by analysing the technical aspects of CLSC (Closed Loop Supply Chains), the process oriented aspects of the circular economy the value creation options and the human factors in the change process.

1.1 Objective

The purpose of this research paper is to examine the extent to which the Returnity program is viable, adds value, and what factors hinder or enable progress.

1.2 Research approach

This research paper is drafted based on literature, semi-structured interviews, observations of Verwol's change agents (Cavagnaro and Curiel 2012) and facts & figures of Verwol. These sources are merged to produce a theoretically sound and practically applicable paper. The Case is described from the perspective of Verwol and of its public- and private sector clients and stakeholders.

1.3 Summary of interpretations and conclusions

The C2C products of Verwol and the fact that it is a manufacturing company provides opportunities to close the loops. What strengthens this is that stakeholders are also increasingly explicitly asking for this. Yet the immediate need for CLSC is not yet there because there are plenty of linear business opportunities. This lack of direct necessity, the convenience of linear sales and the economically risk free character of a linear business model resulted in resistance to change. But there are more factors at play one of which is the lack of a strategic corporate vision, indecisiveness and the limited internal communication efforts. This makes it difficult to embed developments in the organization. Other human factors, like the organizational culture also strongly influence the Returnity program. These factors have

been underemphasized in the implementation of the program to date. The full potential of the program is still far from being exploited.

2. Introduction

2.1 Introduction Verwol

The case I am going to describe is related to Verwol, the firm I work for as a marketing manager. Verwol is an organization who manufacture and assemble fit-out products like wall partitions, doors, ceilings and fixed furniture for offices in The Netherlands. The production part is mainly about the wall partitions and doors and so that's what the factory is set up for and what I put the focus on in this case. The entire process from product development to engineering, production, transport and assembly is done by Verwol with its own people and resources. It's a flat organized firm with 125 employees with a senior management team of 5 (the CEO included). The firm is established in 1976 in Opmeer, Noord-Holland. The practical, down-to-earth approach with which the company was founded suits the Noord-Holland mentality and is still present in the company. In the meantime, however, the company has grown into one of the office fit-out market leaders in the Netherlands with an annual turnover of 50 million euros.

The subject of this paper and the related problem is the progress of the implementation of the circular Returnity program at Verwol. The main research questions are:

- Are Verwol's products suitable for reuse or can they be made reusable?
- Does Verwol have the product stewardship needed to close the loops?
- Is the Returnity program economic viable or can it be made viable, for example by adding services?
- To what extent does the Returnity program add value to the environment? And to what extent does the program have the potential to add value in the future?
- Can we state that the Returnity program connects the C2C products, the product stewardship and the circular economic models in a way that closed loop supply chains occur? Or does it have the potential to change Verwol towards a CLSC oriented company?
- What is the role of stakeholders in the implementation of the program and how does it affect the decision making of Verwol's management?

- To what extent did human factors play a positive and negative role in the implementation of the Returnity program?

2.2 literature review

The literature that is been used is provided by the Open Universiteit, supplemented with scientific articles specifically suited to this case and additional public sources.

3. Methodology

I started studying the literature provided by the Open Universiteit in order to understand the definitions, principles and methods. This literature provided a framework for research questions of this paper, the questions I asked in the semi structured interviews, the type of information I was seeking at Verwol and the experiences of the change agents I formulated.

3.1 Methodology semi structured interviews

A selection of Verwol employees was made for the interviews and the selection was a deliberate one. The interviewees were the financial controller (member of Verwol's management), the head of the factory, the head of the wall partition department / project manager, an engineer, an account manager constructors (direct client) and an account manager architects (stakeholder). This employees were selected because these are the key team members in Returnity projects.

3.1.2 Answering according the Likert scale with explanatory options

The interviewee were asked to answer by using a 5-point likert scale. The likert scale is very useful in measuring views and attitude regarding a subject (Jamieson 2004). Another advantage of this method is that answers can be properly compared. The interviewee was additionally able to provide explanations for the responses. This in-dept possibility of a semi structured interview provided opportunities to discover backgrounds behind the answers.

3.1.3 Three categories of questions

The questions are based on the research questions, the literature and the construction of the article. They were divided into three categories:

- Technical / product oriented questions
- Value related questions

- Questions regarding human factors

3.2 Methodology sources

The sources that are used in this paper are:

- Financial facts and figures of Verwol's actual executed Returnity projects provided insights in the economic viability of the program.
- Financial facts and figures of linear projects at Verwol.
- Literature provided by the Open Universiteit and additional scientific articles.
- Public resources.
- The semi-structured interviews.
- Email correspondence and agenda items. They provided insight into the number, timing and target groups of internal communication activities.
- Finally, my own observations, along with those of the other change agent (Cavagnaro and Curiel 2012), are used in this paper.

In this paper the literature, the data from Verwol, the interviews results and the observation of the change agents were combined to answer the research questions and make solid conclusions.

3.3 Structure

In chapter 4 the case is presented. Emphasized are the introduction, the processes of the implementation, the values of the program, the complex business environment and the decision tradeoffs. In chapter 5 the C2C elements, the product stewardship, the circular economy and the CLSCs are described. Calculations of Returnity scenario's in this chapter provide insights in the economic and environmental values of the program. In chapter 6 the human factors are described and in chapter 7 the interview results are shown. The final part of this paper is about limitations of the study (8), conclusions and discussion (9) and reflection (10).

4. Case: The Returnity Program

4.1 Why this program

Until 2018, Verwol ran only on linear production processes. Products were sold, assembled and then contact with the customer ended. A circular business model should change that

according to the change agents in order to limit the use of raw materials and make Verwol more sustainable from an environmental and economic view.

4.2 The program in a nutshell

At issue is the introduction of the so-called Verwol Returnity program. In this intended Closed Loop Supply Chain Management (CLSCM) program (Krikke, 2020), wall partitions (Verwol's core products) are taken back at the end of use stage. The client will receive a financial fee, as a percentage of the original purchase order, when Verwol can disassemble the wall partitions in good condition at the end of use stage. The returned wall partitions will be sold as second life products at Verwol. Only heights and widths are adjusted but any other recovering activities are unnecessary and be avoided.

4.3 the program now and in the future

The first few years of the Returnity program are devoted to internal introduction, external promotion and the start-up of sales activities. In subsequent years, the goal is to have linear sales decline and increase the Returnity sales. The Returnity sales will consist mainly of newly produced wall partitions with a return agreement. After 5 to 10 years, these will be

returned to Verwol. This offers opportunities for second life sales. An as yet unreleased wish is to include in the program also service aspects and leasing options. No decision has been made on this yet because funding is still an obstacle. Therefore the lease option is not included in this graph.

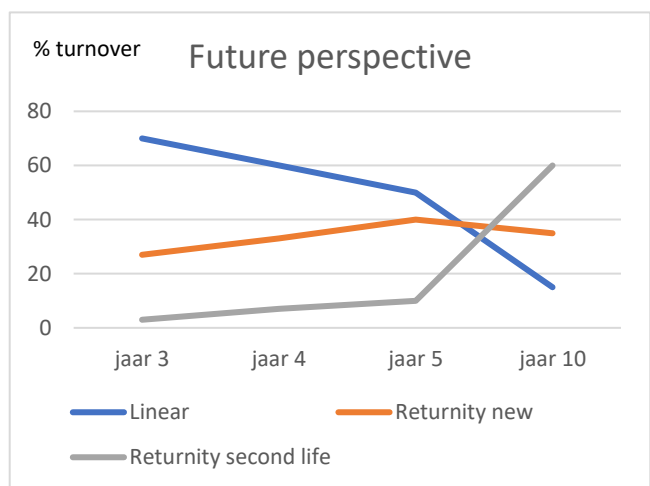


Figure 1: Future perspective

4.4 Client groups

De doelgroep in dit programma zijn de huidige publieke en private zakelijke klanten van Verwol. The program is not specifically developed for customers with limited budgets but aims to reduce a company's footprint (Atasu et al., 2010; Krikke 2011; Kumar & Malegeant, 2006).

4.5 Initiators

The Returnity program is introduced by two change agents (Cavagnaro and Curiel 2012) who took the initiative to start with the CLSC oriented program. The two change agents (Thomas Groot, account manager and Jort Lieman, marketing manager) were involved from the very first meeting up to the implementation.

4.6 Start of the project and progress

The Verwol management responded quickly and enthusiastically to the Returnity concept. Thus, two years ago the change agents did receive an approval from the management and preparations for implementation had begun. Soon afterwards the market launch was a fact. After two years we must conclude that, although market opportunities are there, progress is slow. The current situation is that the vast majority of sales is still linear without any additional services or reverse logistic agreements. The Returnity program is far from reaching its full potential as many CLSCs are far from reaching their full potential (Krikke et al., 2013).

4.7 End of use

In all the linear projects, at the End of Use period the wall partitions are either wasted or the materials are recycled by 3PSPs. This means that Verwol almost never saw its products back in the factory before the introduction of the program. This also meant that it was unknown what value this potential return flow could represented.

4.8 complex environmental environment

The organizational environment is complex. There are many stakeholders influencing the company (and each other) and the exchange of value is divers (Geissdoerfer et al. 2015). Stakeholders exert pressure on an organization to create economic, social and environmental values. They enable, may be obstacles, and act as facilitators at the same time. For example employees: they pressure Verwol to create more environmental value but are prone to falling back into old habits with linear products.



Figure 2: The organizational environment (Geissdoerfer et al. 2015)

4.9 process map

Based on the process mapping techniques of Biazzo (2002) the process steps of the implementation of the Returnity program are identified in table 1.

Table 1: Process step	Action	Result
Initial scanning Q2 Q3 2018	Shaping the idea of the Returnity program and identifying the main characteristics	Having a globally formulated idea.
	Sharing the idea with a potential change agent	Committed change agents (Cavagnaro and Curiel 2012)
	Sharing the idea with Verwol's management	Commitment from management and support to further analyze the idea
Technical Analysis Q3 Q4 2019	Gathering information regarding the technical possibilities for reuse, refurbish and repair the products.	The change agents have made a selection of Returnity products.
Social Analysis	In the implementation of the program, this step has not been sufficiently developed. What the change agents should have done was mapping the social structures and psychological needs of the employees.	If this step was taken then the change agents knew what social structures and psychological needs were important in implementing the program.
External Analysis Q2 2019	Architects (indirect clients) direct clients and 3PSPs play a role in the introduction of the program and their role and interest must be analysed.	The change agents know how to deal with external stakeholders in this program.
Work system design proposal Q3 2019	The technical, social and external analysis come together in a work system design proposal.	A solid implementation plan.

Although it was done unconsciously, most of the steps in the table were followed when the program was introduced. Skipping the social analysis had a negative impact on the success of the implementation (See chapter 6 Human factors). This turned out to be a key factor in the stagnation of the program.

4.10 Value mapping

The value mapping tool (Bocken et al., 2015) provides companies with different stakeholder perspectives and a network-centric rather than firm-centric perspective on value. This tool is useful in indicating where Verwol's current value proposition is focused on and what value is missed and opportunities that can be fulfilled. The current value proposition, the value missed and the value opportunities are indicated with the red dots. The more dots, the more value, missed value and / or value opportunities.

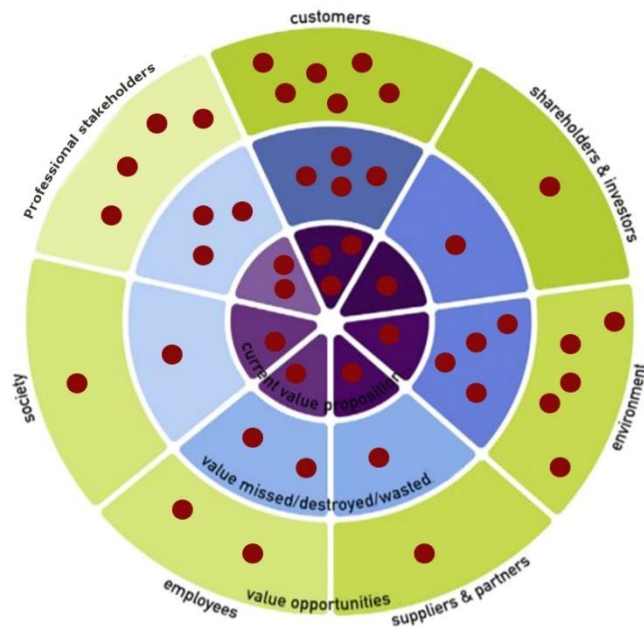


Figure 3: The Value Mapping Tool (Short et al., 2013; Bocken et al., 2015) applied on Verwol and the Returnity program.

4.10.1 Verwol's current value proposition

Verwol's current value proposition is strongly focused on customers and, to a slightly lesser extent, on professional stakeholders. In this case, the professional stakeholders are primarily architects. In every stakeholder group there is value missed and there are value opportunities.

4.10.2 Value opportunities

The most obvious value opportunities are related to the environment, customer loyalty and the financial results for Verwol. The opportunities can be exploited by the Returnity program. The value opportunities related to the environment are exploited by using less raw materials and producing less CO2 emissions (see chapter 5). The customer loyalty is likely increasing because of the return agreement and this should result in additional turnover. The potential value can also be found in additional services for the clients like maintenance, disassembling services, quick repair services and refurbishment services.

4.11 key decisions and trade offs

Although the economic and environmental potential is obvious (this is substantiated in chapter 5), the decision making is complex and there is a certain indecisiveness. The reason for the hesitation in the decision making and following up on it is related to the financial uncertainties. There is no guarantee that returned products can be sold again but return costs and storage costs weight heavily. If, as is the case with Verwol, there is no clear sustainability vision then, from a business perspective, it is best to lean on a linear business model for as long as you can. On the other hand, you can get a head start on the competition now and prepare for the future by working according to circular principles. This continuous doubt in which Verwol finds itself makes the Verwol management indecisive about investing in, and focusing on, The Returnity program. The result is a varying and unclear policy with no focus.

4.12 Short term focus on sales

If Verwol is in competition for a large project, where sustainability is considered important by the client, then different choices are made internally. On a project level, it then suddenly becomes economically interesting to pursue CLSC because it can help to win a contract. However, this short-term policy makes little environmental impact and is ultimately not seen as sustainable by customers.

5 C2C, Product Stewardship, CE and CLCS

This chapter discusses the Cradle to Cradle products, product stewardship and the circular economy processes at Verwol in order to find out if and how it all can come together in the proposed value adding Closed Loop Supply Chains with economic- environmental- and information value.

5.1 C2C in general

C2C products are designed according to the biological- or technical metabolism (Braungart et al. 2006). In the biological metabolism materials are brought back to nature in the form of compost or other nutrients. In the technical metabolism materials of used products can be reused in new products.

5.1.1 C2C at Verwol

At Verwol the most common used materials are glass and aluminum. Both materials that suit the technical metabolism very well because they hardly wear out and can be disassembled and re-used perfectly. Hence, driven by market opportunities and demands, the C2C certification process was started by Verwol in 2015. The initial result was a C2C Bronze certification which was upgraded in 2018 to a C2C Silver level.

5.1.2 Reuse of C2C products

Verwol's products hardly have been reused in the history of the firm. The C2C certification did not changed this at all.

5.1.3. Verwol's motivation for a C2C certification

Verwol aimed for a C2C certificate because the market demands for C2C products was increasing and especially in government related tenders a C2C certificate was a precondition. The result was that manufacturers like Verwol started their certification processes and local governments gave substance to their sustainability policy during a renovation. However, after completing the project, the manufacturer and the client loses contact and in time, with a new renovation, the valuable products are wasted. Hence there are opportunities for the Returnity program.

5.2 Product Stewardship

Verwol's factory is a typical linear production facility where semi-finished products are processed to end products. The teams R&D, logistics, engineering and production are responsible for the development and manufacturing of the products. Together, they do have the product stewardship to control the process from the delivery of semi-finished products to the assembling and disassembling on site.

5.2.1 Lack of returns: on site reparations

There are hardly any commercial returns, recalls, service returns, end-of use returns or end of live returns because of the logistic and handling issues that occur. The wall partitions must be disassembled by specialized workers and the reverse logistic from an office floor to Verwol's factory is complex and valuable. Hence, in case of a warranty/sla request, a team of engineers / workers will visit the location to fix the problem on site instead of bringing back the products to the factory. This on site repair activities extends the period of usage of the

products but at the end of use or end of life phase, the products are disassembled by third party service providers (3PSPs). This is done on behalf of the end user without Verwol's knowledge.

5.3 Circular Economy

The circular economy is a process which aims to keep products, components and materials at their highest value at all times. Lease, rent or sales constructions in combination with services, minimizing emissions, waste reduction and energy leakage by slowing, closing and narrowing material and energy loops (Geissdoerfer et al. 2017) are all part of the circular economy process. Key feature is servitization of the economy.

5.3.1 Benefits of a Circular Economy

The benefits of a circular system are related to finance (see chapter 5.4.1.2), the environment (see chapter 5.4.2.2) and information gathering (see chapter 5.3.6). For Verwol, in particular, it is very interesting to be aware of when a customer is going to rebuild because new opportunities then present themselves.

5.3.2 Circular business propositions

There are three essential elements (Tunn et al. 2019) in circular business model. They are highlighted in Verwol's current situation and in the possible situation with the Returnity Program in table 2.

5.3.3 From product supplier to product servicer

If Verwol can shift from straightforward product supplier to a product oriented servicer intangible value will be added (see table 2). The intangible additional services makes the client willing to pay more than would be justified on the basis of 'rational' calculation (Tukker 2004).

Table 2: essential elements in a circular business proposition

Value	Current situation (linear)	Current situation with the Returnity program	Possible situation with the Returnity program
Customer value proposition (promise)	A fixed, one-time fee for the delivery and assembling of the products. After completion, only guarantees bind the customer and Verwol.	A fixed fee for assembling the wall partitions and a return fee for the client when the products can be collected for reuse.	A stable monthly fee included services, assembling, disassembling en (reversed) logistics.
Value creation and delivery (fulfillment)	Engineering, production, assembling and warranty work according our SLA.	Engineering, production, assembling, maintaining, repairing and disassembling wall partitions according our SLA.	Engineering, production, assembling, maintaining, repairing and disassembling wall partitions according our SLA.
Value capture (bottom line)	One-sided orientation on economic value.	Economic, social and environmental values enabling triple P growth.	Economic, social and environmental values enabling triple P growth.

5.3.4 Circular economy in the public sector

The Netherlands wants to be a circular economy by 2050. It wants an economy without waste, where everything runs on reusable raw materials ([See link Rijksoverheid.nl](https://www.rijksoverheid.nl)). It is therefore understandable that building projects commissioned by the government should be subject to high sustainability requirements. Especially because the construction sector is the world's largest consumer of raw materials, and accounts for 25-40% of global carbon dioxide emissions. Literature on CE in the built environment is limited but the concept is gaining momentum in the construction sector. The shared founding principles lie in the better management of resources. (Pomponi and Moncaster, 2016).

5.3.5 Circular economy in the private sector

Increasingly, private sector companies are aiming to buy and supply products and services in a sustainable way (Walker and Jones 2012). Large corporates often are pushed by stakeholders to move towards a circular economy and take these interest into account in their office fit-out demands. Smaller companies with less stakeholder pressure and resources are usually focused more on direct costs than the circular economy in their housing plans.

5.3.6 Circular economy in the construction sector

Construction uses a relatively large amount of recycled materials 37,9% (see link [CBS.nl](https://www.cbs.nl/en-gb/indicatoren/10000-2010)) but there are no reliable figures on the percentage of materials that are directly reused, repaired or refurbished. Zooming in on the wall partitions, as a part of the construction activities, we lack figures as well. However, it is well known that the market leaders in the business hardly reuse their products.

5.3.7 Verwol and the ability to work according to principles of a circular economy

Verwol is able to follow the principles of a circular business model because:

- The design of the Verwol products are very long lasting in terms of technical features. Ever since the start of Verwol in 1976 no products have been signalized to have reached their end of life stage so the maximum utilization period is unknown. The end of use phase is often related to relocation of entrepreneurs (average 10 years) and changed aesthetic wishes.
- Material costs weigh heavily in a project (about 50% of total cost) so reuse can pay off.
- The added value of Verwol (Table 1) is currently rather one-sided but can be upgraded without insurmountable problems because Verwol has already the resources to add services to its proposition.
- There is a general understanding in Verwol's management how
 - o the collecting process should be organized
 - o reverse logistics should be implemented in our processes
 - o Verwol is able to repair, restore and reuse the products

5.3.8 Verwol and the disability to work according to principles of a circular economy

There are also obstacles that inhibit Verwol in upscaling the circularly framed Returnity program:

- There are financial uncertainties related to reversed logistics, storage cost and reselling chances. Verwol does not know if, how and when they can make a viable business model of the Returnity program.
- A linear model the financial model is straightforward: a client buys wall partitions with a warranty period and there are no obligations after that. A circular model is more complicated. In case of leasing or renting construction Verwol needs to prefund the products. In case of take back programs, Verwol must take into account future costs. Selling new products is seemingly less labor-intensive and with fewer risks. That said, in linear processes there is a lot to be invested in acquisition processes where CLSM leads to higher customer loyalty and profitability.
- There is little intrinsic motivation for sustainability at Verwol's senior management. Although sustainability is not the same as closed loop supply chain management (Geissdoerfer et al. 2017), the concepts are in a way related to each other in this case.
- There is no direct economic need for change because the firm is doing well with linear sales models.

5.3.9 Vicious cycle

The fact that there is no direct economic need for change, the little intrinsic motivation for sustainability and the uncertainties of the financial benefits creates a vicious cycle. (González-Torre et al., 2010). It would be beneficial for the progress to have a direct need for change, limited uncertainties and / or a strong intrinsic motivation. The vicious circle can be broken by better identifying the financial risks and increasing customer demand. The interview results show that the motivation for sustainability is present in a large part of the employees.

5.3.10 External factors in the progress of the Returnity program

External factors such as infrastructure, governmental policies, or customers' perception that recovered products are of poorer quality (Abdulrahman et al., González-Torre et al., 2010; Zhu et al., 2014) can accelerate or slowdown circular economy initiatives. In the Returnity case at Verwol external factors accelerate the progress because (indirect) clients increasingly demands second life products.

5.3.11 Internal factors in the progress of the Returnity program

The organization-internal factors such as company policies, and financial constraints (Kapetanopoulou & Tagaras, 2011) are the limiting factors. And, it can be concluded that internal and not external constraints are most important in CLSCs (Schenk, Krikke, Caniels, Lambrechts 2019). The absence of top-management commitment (Ravi & Shankar 2005) impedes implementation.

5.4 Closed Loop Supply Chains

The Cradle to Cradle products, product stewardship and circular economy create potential and favourable conditions for reuse and recycling. But does it all comes together in a closed loop supply chain management process with actual economic, social and environmental value? In this chapter the economic and environmental value will be mapped. The figures are based on actual executed projects but are converted to a virtual project in which the circumstances are equal to make a comparison possible.

5.4.1 Environmental value

In order to indicate what the environmental value of the Returnity program the impact in terms of CO₂ emissions in a project is mapped. The impact of a linear project is calculated and compared to a Returnity project with the same project characteristics. In both the linear case and the Returnity case, new wall partitions are installed in the first project. In the linear case, the wall partitions are recycled after each project and new wall partitions are produced for the next project. In the Returnity program, the wall partitions are reused in the second and third projects before being recycled after the third project.

5.4.1.1. Factors in this project

- The project is in Utrecht, 100 km from Verwol's factory. In the case of the Returnity program, future projects are in Utrecht as well.
- The project contains 500m² of wall partitions type [Verwol Slimline Clearvision 100](#) with a height of 2.70m (height is important to calculate the glass / aluminum ratio).
- The wall partitions are made of 99.5% glass and aluminum. The other 0,5% of the materials (rubber 0,16%, silicon 0,19 and 0,15% metal and plastic) are ignored

because of the minimal quantity. See appendix B for a material passport of this product.

- No CO₂ is emitted in the use phase of the products.
- In this case the wall partitions can be reused 3 times for 3 different clients in a period of 30 years. Although the technical end of life stage is not reached after 30 years, it is not realistic to assume Verwol can sell the wall partitions a 4th time because of changed esthetical and functional wishes.

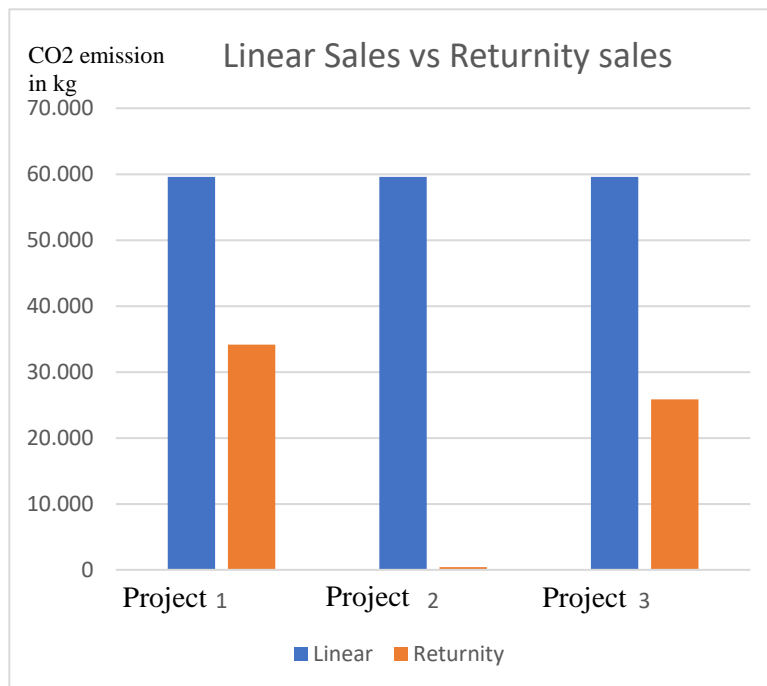


Figure 4: CO₂ emissions in a linear project versus a Returnity project

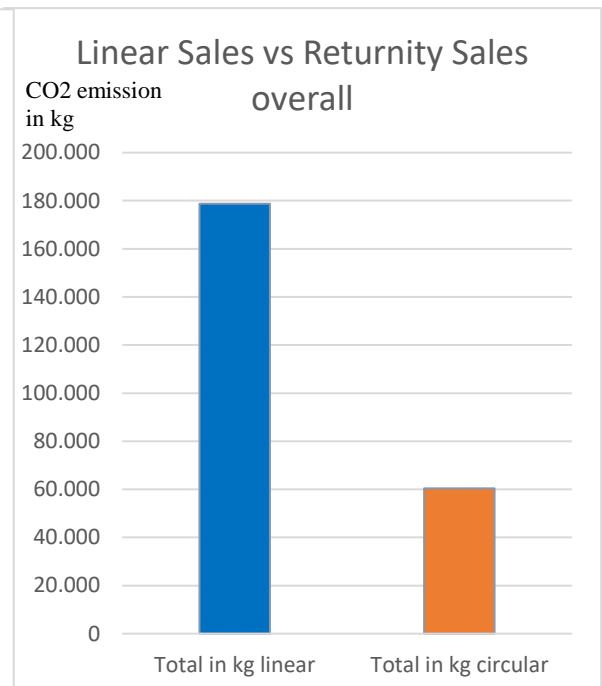


Figure 5: Overall CO₂ emissions in 3 projects

5.4.1.2 Environmental results

Results project 1: In both scenario's (linear vs Returnity) the wall partitions are produced new. Yet CO₂ emissions are much higher in the linear scenario than in the Returnity scenario. This is due to the recycling process. Recycling is seen as an environmentally conscious choice but the figures from project 1 show that reuse is much more sustainable.

In project 2 the linear impact on the environment is as much as it is in the first project and the CO₂ emissions in the circular case are limited to transportation. In project 2, the savings in CO₂ emissions are the greatest.

In the third project the wall partitions in the linear project and the circular project are both recycled. The CO2 emission in the Returnity scenario is lower than in the linear scenario because, as in project 2, there is no need to produce.

The results show that the Returnity program is always environmentally less harmful than linear production. See appendix C for the calculations.

5.4.1.3 Sources used in the environmental calculation

The sources used for this model:

- The Material Passport of the Verwol Slimline Clearvision 100 provided information on the materials in kg per m2 of the product used in this case (see appendix B).
- <https://www.environdec.com/library> for product declarations of aluminum which provided information of the CO2 emissions in the production process of the materials.
- The milieubarometer provided information of the CO2 emission of transport per km.
- The article ‘CO2 emissions in the recovery and recycling of aluminum from MSWI bottom ash’ and the article ‘throwaway-culture-the-truth-about-recycling’ provided information about the CO2 emission of recycling glass and aluminum.
- An environmental product declaration of AGC, the glass supplier of Verwol.

5.4.2 Economic value

In order to indicate what the economic value of the Returnity program is for Verwol, the financial results of a project is mapped. The results of a linear project is calculated and compared to a Returnity project. The same characteristics as in 5.4.1 are used. See 5.4.2.1 for the additional financial factors that have to be taking into account in the comparison of the linear and the Returnity project.

5.4.2.1 Financial factors in the comparison between linear and the Returnity project

The linear projects of Verwol and the first actual Returnity projects provided calculation factors which are used in this case and summarized in table 3. The calculation of the leasing model is based on assumptions and logical calculation models for lease structures because there are no leasing projects at Verwol yet. The return fee is about 25% on the material cost. However, it is not included in the calculation because in practice it balances with the profit margin on the disassembly job. The disassembly job is performed in linear projects by 3PSPs.

In Returnity projects, this is done by Verwol. This can therefore be seen as guaranteed extra income that can be spent on the return fee and therefore does not need to be included.

Table 3: price structure	Linear sales	Returnity sales (no services)	Returnity lease (add services)
Usage period	10 years	10 years	10 years
Second life price (compared to original price)	-	80% of the original price	80% of the original price
Third life price (compared to original price)	-	70% of the original price	70% of the original price
costs for repairing the products (including labour and product replacement)	-	+15%	+15%
equipment and logistics cost	100%	100%	100%
labour cost in the assembling	100%	105%	105%
Storage costs	-	€10,- per m2 a year, max 1 year stored	-
Overhead costs	19%	19%	19%
Profit rate	10%	10%	10%
Interest rate	-	-	6,5%
price structure	Material, labour, equipment, interest, overhead (including insurance and logistics), and profit	Same as linear sales plus disassembling, reverse logistics	Same as Returnity sales plus maintenance. This prices is divided by 7 (depreciation period) and multiplied by 10 (leasing period)

5.4.2.1 Economic results

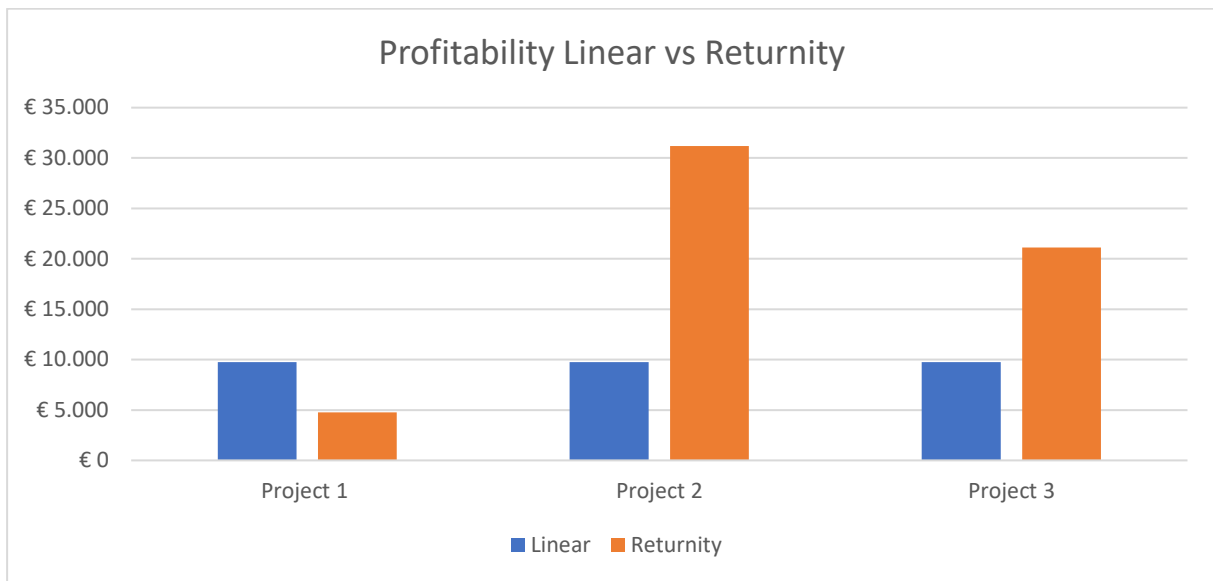


Figure 6: Profitability linear versus a product oriented Returnity approach in a theoretical setting

Figure 6 shows that the profitability of a product-oriented Returnity approach is lower than a linear approach in the first project. This is because of the logistics-, storage and handling costs related to returning the products to the factory. In the second and third project it's the other way around because there are no production cost in the Returnity scenario anymore. The profit in the third project is lower than the profit in the second project because of the decreasing sales price. See appendix E for the calculation model used.

5.4.2.3 Competition between linear and circular offers

Figure 6 assumes competition between a linear supply and a circular supply in a project. This turns out to be rare in practice because a customer is specifically looking for a circular provider. In that case there is no profit at all in the second and third project of the linear scenario.

5.4.2.4 Potential value of leasing concepts

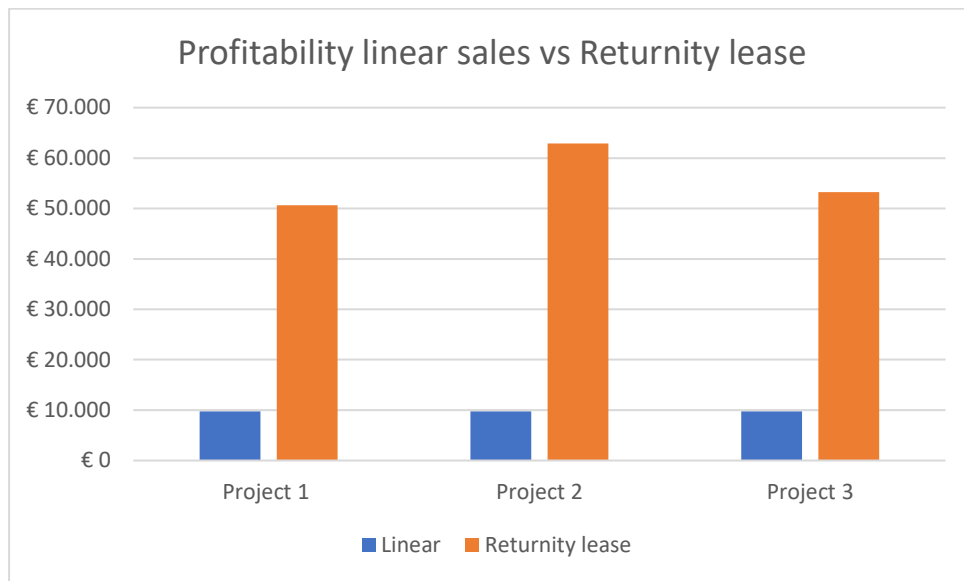


Figure 7: Profitability linear versus a product oriented Returnity approach in a theoretical setting

Figure 7 shows the profitability of a lease construction with additional services in the Returnity program compared to a linear sales scenario. It is clear that the leasing program is much more profitable than the linear business model. The profitability of the leasing concept is at its highest in the second project because of the lack of material costs and the relative high second life sales price. In the third project there are no production costs as well but the sales price is decreasing so te profitability as almost equal to the first project. See appendix E for the calculations.

5.4.2.5 Barriers value of leasing concepts

Financing is a barrier in introducing the leasing concept. To date, there are no lenders willing to provide financing and Verwol is not financially strong enough to provide the prefinancing itself. The first step before further exploring leasing concepts is finding a funder.

5.3.6 Information gathering value

The value of the information gathered with the Returnity program cannot (yet) be expressed in numbers. This will only be possible once the first returns and an increasing number of second life projects have taken place. However it is very likely that the customer loyalty will increase. The information gathering value of a CLSC is underestimated at Verwol. When there is a return agreement with the client than the client needs to inform Verwol if they are going to renovate their office. This leads to new business opportunities in several ways:

- It's likely that the client moves to another location where again wall partition are required. There is a good chance that Verwol may make an offer for this while this opportunity might not have come to mind without the Returnity program.
- If the client moves, it's also likely that a new company will use the office the client of Verwol is leaving. Verwol is the first to know this acquisition opportunities.
- When the client no longer will use the wall partitions, Verwol is the one to disassemble the products in the Returnity scenario. This will generate additional turnover instead of disassembling by 3PSPs.

6. Human factors

6.1 Organizational Culture

The organizational culture has had both an accelerating and an inhibiting effect on the change process toward closed loop supply chain management. The accelerating effect caused a swift introduction of the program but the culture also caused stagnation of the implementation progress.

6.1.2 Three levels of culture

The organizational culture is highlighted according to the three levels of culture (Schein, 2004). The three levels are artefacts, espoused beliefs and values and underlying assumptions. Figure 8 provide an overview of Verwol's culture based on this three levels.

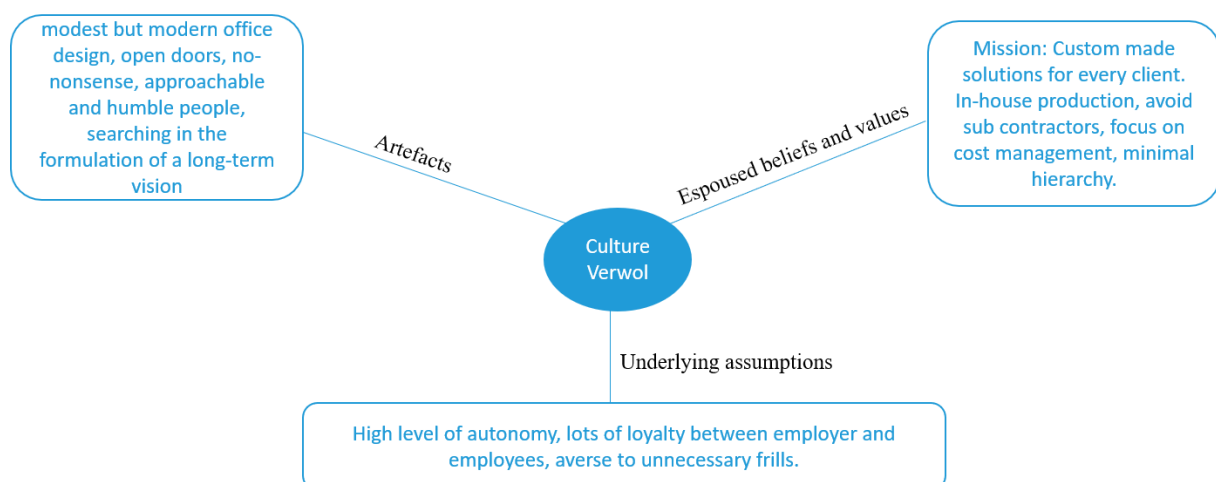


Figure 8: Overview of Verwol's culture

6.1.3 Advantages linked to culture in the implementation phase

The fact that there is little hierarchy and a great deal of autonomy made it possible to work out a CLSC idea and pitch the idea of the Returnity program to Verwol's management. The change agents were able to approach the CEO without any reluctance. The pitch itself was somewhat complicated because there is no strategic corporate vision and no clear position on sustainability. The CEO had to be convinced by indicating the potential economic benefits and emphasizing the current and increasing value that customers place on sustainability.

Verwol's CEO and management gave the green light for the preparation and introduction of the program. An instant theoretical change towards a more sustainability policy was made.

6.1.4. Disadvantages linked to culture in the implementation phase

The disadvantage of the organizational structure without much hierarchy is that a decision taken is not followed without question. In this case, the decision to start the Returnity program should have had a great deal of impact on Verwol's operational practices. A reverse logistic plan, a business model, an operational guideline and process flows were drafted and teams were informed. However, after lining up all involved departments (basically the whole organization including sales, engineering, logistics, workers, production facility, finance and project management) everybody soon returned to their business as usual habitats. It is likely that the underlying assumptions plays a role. The underlying assumptions are reflected in the great deal of autonomy an employee have at Verwol. If you disagree with a change of direction you can simply neglect to follow up. However the company/employee loyalty is strong and an employee feels the responsibility to do the right thing for Verwol. It is likely that the other human factors also play a role in the stagnation of implementation

6.1.5 Cultural advantages and disadvantages in one path

In the implementation of the Returnity program Verwol's culture worked both advantageously and disadvantageously. After the initial introduction, adverse cultural effects had a heavy influence.

6.2 Resistance to change

Whenever there is change, there is also some force pushing in the opposite direction. Belliveau et al. (2004). This was the case in the implementation of the Returnity program as well. This chapter (6.2) discusses the various factors that played into resistance to change.

6.2.1 Resistance to change by leaving the comfort of the current state

The initiators of the Returnity program argued why production levels should be minimized and reuse encouraged. This while Verwol is used to pursuing maximum production levels for maximum profit ever since the establishment of the company in 1976. Prosci (2005) stated that resistance to change is often not specifically caused by the reason for change itself, but rather by leaving the comfort of the current state. This certainly applies to Verwol. From an organizational perspective there is no immediate need for change. Selling linear is less complex, profitable in the short term and one is familiar with the method.

6.2.2 Resistance to change as a result of a lack of shared understanding and incentives

The lack of shared understanding and incentives (Abdulrahman et al. 2012) fuelled resistance to change. The interviews showed that there is latent motivation for sustainability but Verwol never put effort in finding and describing shared sustainability understandings. logically, therefore, there are no incentives linked to sustainable action.

6.2.3 Resistance to change as a result of a lack of internal communication

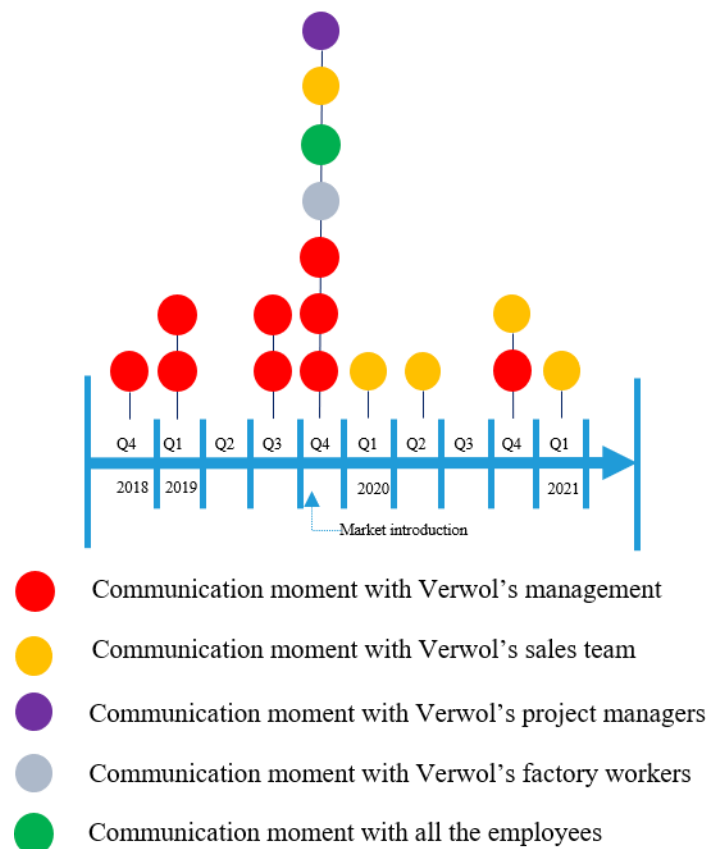
Internal communication activities are very limited. Communications regarding the implementation of the Returnity program was mainly focused on external stakeholders like architects (indirect clients) and contractors (direct clients). In table 4 the internal communication subjects, attendees and type of communication (Verhulst and Boks, 2012) are listed. Figure 9 shows the communication data in a timeline and looking back on the process, the information sharing, which is an important factor (Verhulst & Boks, 2012), was insufficient.

Table 4: internal communication and type of communication data based on Verhulst and Boks (2012)

Date	Subject	Persons involved	Platform	Type of communication
Dec 2018	First introduction to the idea	CEO	Informal verbal communication	Involvement and empowerment
Jan 2019	Pitch outlines CLSC program	Senior management	Presentation in board meeting	Involvement and empowerment
March 2019	Presentation Returnity program	Senior management	Presentation in board meeting	Involvement and empowerment
Sept 2019	Redefinition of financial principles	Senior management	Email	Process supporting tools
Oct 2019	How to implement the Returnity program?	Wall partition manager and an sales representative	Meeting	Involvement and empowerment
Oct 2019	Introduction Returnity program	Project management team / CEO	Meeting	Spreading of information
Oct 2019	Introduction Returnity program	Factory workers / CEO	Meeting	Involvement and empowerment
Nov 2019	Establish logistic plan, financial plan and operational plan	Senior management	Presentation in board meeting	Process supporting tools
Dec 2019	Sharing Returnity goals 2021	Sales & marketing team	Presentation in sales meeting	Spreading of information
Dec 2019	Introduction Returnity program	All employees	Email / website	Spreading of information
Feb 2020	Presentation Returnity program	Sales & marketing team	Presentation in sales meeting	Spreading of information

April 2020	Update presentation Returnity program	Sales & marketing team	Presentation in sales meeting	Process supporting tools
Oct 2020	Progress update Returnity program	Sales & marketing team	Presentation in sales meeting	Spreading of information
Dec 2020	How to revitalize the program	CEO, sales representative, marketing manager	Returnity meeting	Involvement and empowerment
Jan 2021	Recap: Returnity why and how?	Sales & marketing team	Presentation in sales meeting	Involvement and empowerment

] Figure 9: internal communication moments



Reflecting on the communication efforts there was attention on internal communications in the preparation stage at management level and company-wide communication at the moment of market introduction. Soon after the introduction, frequent and divers internal communication was missing.

6.3 Empowerment and involvement

Kirkman and Rosen (1999) define four dimensions of empowerment:

- 1: group potency. There is no question if Verwol's employees are capable to make the Returnity program successful because all the technical knowledge and the experience with all the elements of CLSC is there.
- 2: meaningfulness. The interviews indicated that the majority of the employees consider the program meaningful. The common ground in the answers was that they recognize the future potential in economic terms and appreciate the sustainability aspects of the program but did not see the immediate need to change.
3. autonomy. There is more than enough autonomy present (see chapter 6.1) in the way employees complete their tasks.
4. impact. The strength and influence of employees in this process is often neglected within the field of sustainable design. (Verhulst and Boks 2012). This proposition occurs at Verwol. Based on observations of the change agents, employees underestimate the impact they have in the success of the Returnity program. In the experience of the change agents a customer is happy to change its linear demand into a circular solution but must be made aware of the opportunities to do so.

6.4 human factors in time

At the introduction phase of the Returnity program the reaction of Verwol employees and other stakeholders was positive. This is no surprise since customer demands and changing, legislation is upcoming and pressure from different stakeholders to move towards a more sustainable business model is increasing (Sarkis et al., 2010). The company culture, lack of internal communication, lack of immediate economic necessity and the lack of management vision made the positiveness regarding the program weaker over time. This was also the case with the change agents which caused the implementation process to stagnate.

7. Semi structured interviews

The interviews served as a test to determine whether the analysis of the technical aspects, the value attributed and the human factors described in this research paper matched the perceptions of Verwol employees. It also provided a future perspective from the employees' point of view and gave insight into obstacles experienced through the structure of the interview with follow-up questions. The questions and answers on the likert scale are listed and compiled by category in table 5. The scale ranges from 1 (very negative with respect to the question) to 5 (very positive with respect to the question). The explanatory notes are presented in appendix F. Finally, this court document presents the conclusions of the interview. These conclusions are also incorporated into the remaining sections of this research paper.

7.1 Interviewees

Interview	1	March 2021	Marjon Vermeulen	Account manager Architects
Interview	2	March 2021	Pim Obdeijn	Member of Verwol's board and financial controller
Interview	3	March 2021	Marcus Schook	Manager department wall partitions and project manager
Interview	4	March 2021	Niels Bakker	Account manager constructors
Interview	5	March 2021	Johan Borg	Head of the factory
Interview	6	March 2021	Alex Top	Engineer

7.2 Questions and answers on the Likert scale with explanatory notes

Table 5: Interview results

	Int. 1	Int. 2	Int. 3	Int. 4	Int. 5	Int. 6	Average per question	Average per category
Technical oriented questions								
1.To what extent do you consider our products suitable for reuse?	4	4	5	5	4	4	4,33	

2.To what extent do you think we have the product stewardship to reuse the products?	4	4	2	4	3	5	3,67	
3.To what extent are we capable to return / relocate our products?	4	2	4	4	1	3	3,00	
4.To what extent are we capable to refurbish / repair our products?	5	4	5	3	1	3	3,50	3,6
Value oriented question								
5a.To what extent are we capable to add services like maintenance?	5	5	5	5	4	4	4,67	
5b. To what extent are we capable to add quick repair services?	4	3	4	4	1	4	3,33	
5c. To what extent are we capable to add disassembling and / or reassembling services	5	5	5	4	4	5	4,67	
6. To what extent do you think services will be valuable for a client?	5	4	5	4	4	5	4,50	
7. To what extent do you think services will be valuable for Verwol?	5	4	5	4	4	3	4,17	
8. To what extent do you think these services extend the life of the products and thus	4	4	4	4	1	2	3,17	4,1

contribute to environmental goals?								
Human Factors related questions								
9. To what extent do you consider the Returnity program financially viable?	5	3	3	5	1	4	3,50	
10. To what extent do you consider the Returnity program necessary for the environment?	5	5	5	4	1	4	4,00	
11. If it were entirely up to you, to what extent would you commit as a company to the Returnity program?	5	3	5	4	1	4	3,67	
12. To what extent do you think our corporate culture facilitates the implementation of the Returnity program?	3	1	1	2	1	2	1,67	
13. To what extent do you personally experience positiveness or resistance to the introduction of the program? 5 is very positive so no resistance, 1 is very much resistance	5	4	5	3	2	5	4,00	
14. To what extent do you think the group of	3	4	4	4	1	2	3,00	

Verwol employees is capable to make a success of the Returnity program?								
15. To what extent do you think there are sufficient tools to implement the program?	5	2	2	2	1	4	2,67	
16. To what extent do you think you are sufficiently informed about the program?	5	2	2	4	1	4	3,00	3,2
	Int. 1	Int. 2	Int. 3	Int. 4	Int. 5	Int. 6		
Average technical oriented questions per interview	4,3	3,5	4,0	4,0	2,3	3,8		
Average value oriented questions per interview	4,7	4,2	4,7	4,2	3,0	3,8		
Average human factors questions per interview	4,5	3,0	3,4	3,5	1,1	3,6		
Overall average (all interviews and al categories	4,5	3,5	3,9	3,8	2,0	3,7		

7.3 Analysis of responses

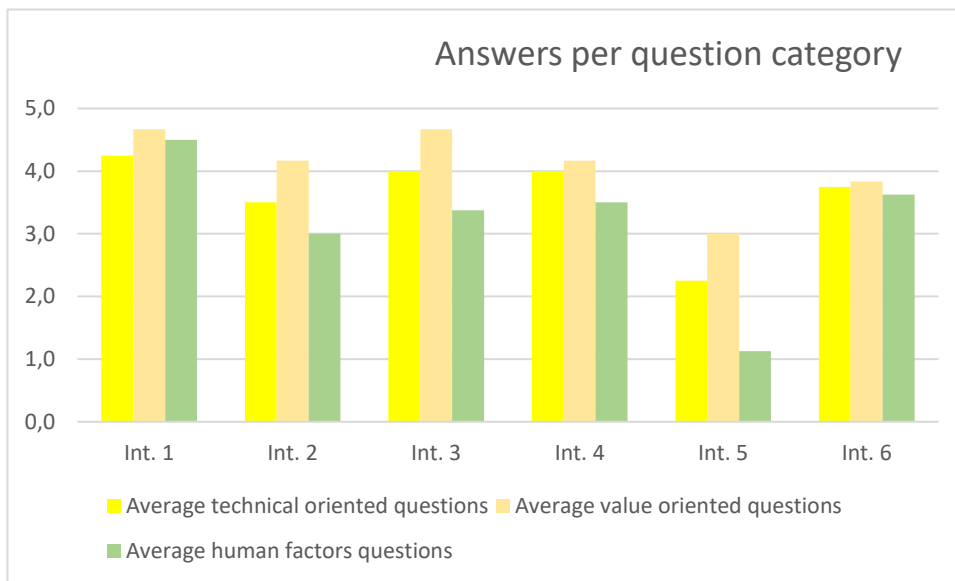


Figure 10: analysis of the responses

The value-related responses were answered most positively followed by the technical oriented questions. Interviewees are least positive about human factors in the program with the lowest rating for the effect of the corporate culture on change. The responses in the fifth interview differed significantly negatively from the other interviews.

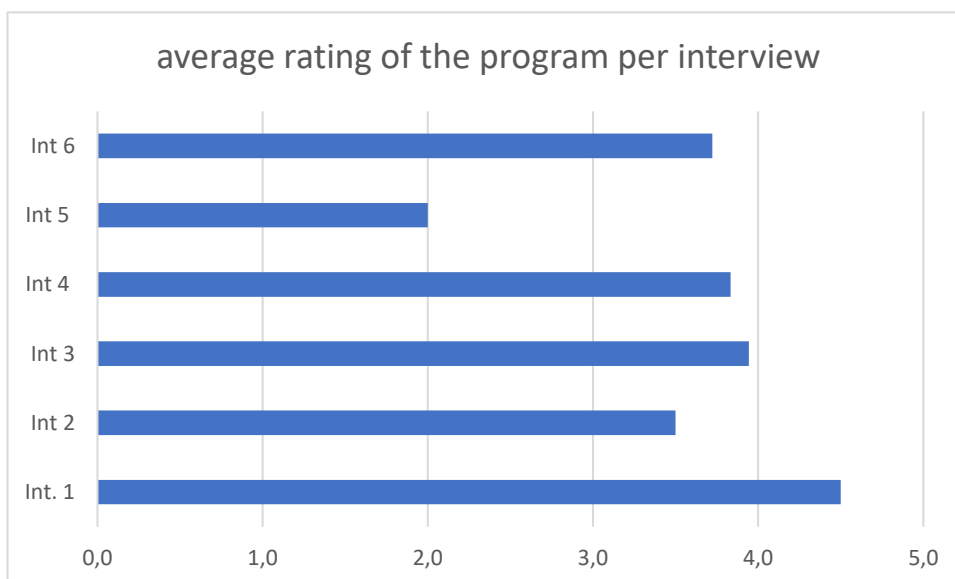


Figure 11: analysis of the responses

Apart from the 5th interviewee, (the manager of the factory) the respondents are quite positive towards the present situation and the potential of the Returnity program. They don't see any

insurmountable technical problems and, although there are logistic challenges, they see the added value in terms of economics, environmental and customer loyalty.

The in-dept answers were useful to identify drivers and obstacles. In a way, it was surprising that all but the factory manager interviewed mentioned that they considered the environment to be very important. It was surprising because this is not reflected in their work and the affinity regarding the subject was never discussed. The obstacles were mainly practical and could be overcome with a thorough approach .

7.4 Improvement actions

The interview results shows that human factors need the most attention in order to boost the Returnity program. Especially a vision, encouragement and support of Verwol's management is required. This in combination with practical tools, work descriptions and task allocations will help the program to proceed. To be specific the following documents, guidelines and policies needs to be drafted:

- Drafting a strategic corporate sustainability plan is the first step that has to be taken in order to embed the program.
- Detailed calculation models which makes it very easy for the sales team to make quotations for the Returnity program
- A standard chapter in the quotation templates
- A 'mining plan' which gives substance to the product acquisition
- A reverse logistic plan
- A sales and marketing plan
- An internal communication plan
- A progress report structure

The negative attitude from the head of the factory toward the program is worrying. Especially the lack of interest in environmental values and the disbelief of the economic potential is a problem since he is a key player in the execution of the program. A customized approach aimed at inspiring, informing, convincing and motivating this factory manager is a necessity. This customized approach should be drafted by management together with the change agents.

8. Limitations of the study

The most important limitations in this study are:

- There is insufficient market research to assess the market potential of second life products. In particular, the question of whether second life sales cannibalize linear sales is interesting to test the economic feasibility.
- The number of interviews is limited. Ideally, you would interview a larger group of employees to get a better picture.
- The number of Returnity projects actually executed is limited. When this number has increased then the process has been refined and a sharper analysis is possible and financial uncertainties are minimized.
- After the first decade of Returnity projects future research must reveal if customer loyalty is improved due to the CLCS program.
- The social value is difficult to measure on a micro scale (Verwol) and statements about it can only be made after a broader CLSC implementation across the construction industry.

9. Conclusion and discussion

Generally speaking Verwol employees and customers consider the walls and doors suitable for reuse. This is validated by the C2C certificates and Verwol's product stewardship. The first process steps have been made to set up the circular Returnity program though clsc is still not a primary business at Verwol. The potential to change towards a CLSC oriented company is there.

It is abundantly clear that the Returnity program add value from an environmental perspective. The CO2 emissions in Returnity projects are significant lower than in linear projects. It is likely that both private and public customers and other stakeholders will place even greater value on circular business models in the future than they do now.

The economic viability of the program is bright but uncertain in the current situation. In a single client case, the linear project seems to be the most profitable but it is not fair to assess this way since clsc is per definition not about a single project. In addition, it is very likely that customer loyalty will increase as a result of the Returnity program only this is not yet provable with figures.

Adding services like maintenance and quick repair services will be valuable for Verwol in terms of profitability and improved customer loyalty. Maintenance might extend the lifetime of the doors but the end of life phase is never reached in the current situation. However, with the Returnity program, this can be pursued.

Leasing services are even more profitable for Verwol but financing is a barrier. From a client perspective the services are considered valuable as well.

Stakeholders like clients, indirect clients and a selection of employees are influencing Verwol's management and urging them to close the loops and reuse products. They act as a catalyst for sustainability at Verwol. However, as long as sustainability is not embedded in a vision, there is a lack of decisiveness and focus

Human factors have been underestimated and even somewhat ignored in the introduction of the Returnity program. This is a major reason why implementation has stagnated.

Policies on human factors and the removal of operational blockages provide great opportunities for the further development of the program.

The findings from this article can also be applied to other construction companies. However, there are two conditions: 1 Work must be done with materials that are stable in value. 2: The cost price of the materials must be a significant part of the total cost price to make reuse profitable.

Future research should reveal the level of demand for second life products in the construction industry. So far, demand has exceeded supply and attention to reuse from public and private parties seems only to be increasing. It is therefore advisable for construction-related companies to pay attention to CLSC management.

10. Reflection

As one of the two change agents I initiated and implemented The Returnity program at Verwol. At the implementations we did not have calculated the environmental and economical impact as precise as I did in this research paper. This insights will help me to convince internal and external stakeholders. The environmental calculations surprised me, in particularly the recycling figures. I didn't expect recycling to be so environmentally damaging.

The CLCS literature and the assignments made me realize that we should have prepared and executed the implementation more consciously and carefully. We did not pay much attention to human factors and the focus was on sales and marketing, not on internal communication. We also underestimated the necessity of an elaborate operational plan. We did provide some basic tools but they did not sufficiently remove the barriers to getting started with the Returnity program. If research questions from this paper had been asked before the introduction of the program then the implementation would have gone more smoothly.

The program must be relaunched internally, and I feel more equipped to do now after finishing this CLSC module. I will start challenging the management to provide a vision towards sustainability which is needed to embed The Returnity program. I am looking forward to set-up an always ongoing internal communication plan, a product acquisition plan, a sales & marketing plan and work in a team on a proper operational plan including logistics.

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Appendix A Evaluation of a Returnity project

Second Life wanden How to



Second Life walls How to

Introduction

In 2020, the 200450 Dopper (Oceans) project came the way of Verwol as a Returnity program. In other words, (re)assembling 2nd hand walls. A project that we won because we were the only one that would reuse the existing glass where others wanted to supply this new. (The glass to be reused was hollow sphere and was about 400mm too high for the new location)

The following is based on the experience of this project where ESD walls were reused which were dismantled without prior knowledge of reuse on a project and subsequently sold at the Dopper project where the walls had to be lowered by approx 400mm.

Sales and marketing

Are they Verwol walls or third-party walls?

Verwol

Look up the existing work number to see what exactly the walls are, if necessary contact the planner in connection with any snags or specials relating to the walls and doors/frames.

Third parties

If necessary, know the supplier in order to find out the data.

Type of system and thickness of walls (for possible adjustment with own profiles).

General items that always apply:

1. Height existing situation and new situation.

- Too high must be cut but this can only be done with laminated glass.

(Toughened glass is unprocessable and can only be replaced 1 on 1 in combination with new)

- too low can be solved with pressure bulkheads above the walls.

2. When too high how to solve with doors / frames.

Hinges, lock height etc.

3. Are existing walls covered with foil? Standard films are easy to remove but 3M film is very labor intensive.

4. Storage of materials, where and how long (discuss with Johan outside the door is eg.

Kaspers storage is an option)

5. Determine with the customer what is acceptable to reassemble and what is not.

They are second life products so in principle they will never be like new.

Profiles may have scratches or mounting holes, doors may have cylinder cylinder holes and glass can have scratches etc.

Calculation

Important points to consider when calculating Second Life Walls are:

1. When disassembling, time (and therefore money) must be spent on marking, bundling and packaging the materials.
2. Shortening glass in height should be outsourced for larger quantities (more than 10 panes). These are expensive actions because this is not a regular working method within our suppliers and there transport and handling of the glass.
3. Cleaning the glass, removing any foils (note 3M foil is very expensive) and taping on the longitudinal sides for hollow/bulb, tape or flushjoint joints. The suppliers do not want to do this because they are not equipped for this and therefore "must" if they (the suppliers don't want to do this because they are not equipped for it and therefore "have" to add it if they do, and charge a high price).
4. If the parts are not sorted out, sorted and counted during disassembly, this still has to be done at the factory.
5. When glass has to be cut in height, this normally also applies to doors and frames.
6. when glass has to be cut in height, does this normally also apply to doors and frames. If this works out with the hinges then time must be calculated for this in the factory.
7. The disassembly and certainly the reassembly of walls of third parties takes more time and involves more risk because we have no knowledge of these walls and in principle also no materials for repair.

Work preparation

Before starting work, it is important to determine the extent to which the plan will be worked out on paper in consultation with the project manager and executor.

We know little or nothing about third-party walls and therefore cannot draw them out in detail, and the opposite obviously applies to our walls.

1. When it comes to third-party walls, find out what data can be found. Any
Any details or on the basis of the dismantled material determine what deductions and set sizes are.

2. Has the disassembled material already been disassembled or does it still need to be disassembled? If already dismantled, is this all recorded on a list and marked, if so then you can further. If not, determine whether all this still needs to be done in

Opmeer so that

If not, determine whether all this still needs to be done in Opmeer in order to be able to work out further and determine how we will end up with materials.

If the walls still need to be dismantled, are they ours and do we therefore already have 90% of the data or do they belong to third parties? In the latter case, everything will have to be counted and marked on site. The more that is known and determined in the preliminary stage, the more benefit you will have in the further course. further course. Putting time into this will save time later.

3. Setting up a working drawing with a floor plan with dimensions is the minimum.

Supplement this with any views generated via cwall, details, etc.

Find out in accordance with std. Demo/ Herno working method what can be reused unless in consultation and the customer agrees that this will all be determined on the job.

When sorting out and working out beforehand, use the codes that were used during disassembly.

4. Determine/consult where and by whom certain operations and activities will take place.

- Working on glass, profiles and doors/frames.
- Selecting and sorting materials
- Cleaning materials.

5. After approved drawings drawing lists for the assembly and either have this ready or In consultation send all the material and sort it out on location.

Execution Disassembly

When it is known that materials will be used for reassembly/ second life do the following actions.

1. Disassemble materials with care, store on trestles/ pallets and pack.
2. Bundle profiles together (keep clickers near bins and brackets near frames, etc)
3. Keep frames and doors together as sets or mark them. (in the case of dopper there were many different frame/door heights but without marking all the door carts and stiles and sills on 1 trestle mixed together.
- 4.. Maintain summary list of type, dimensions and numbers.
5. Definitely mark the glass but possibly also profiles and keep track on the summary list.
6. Consider with Projecleider/ Factory to clean materials already on site. (remove films, tapes etc)

Working drawing

1. Set up working drawing with a floor plan with dimensions is the minimum.
Supplement this with any views generated via cwall, details etc.
2. Find out in accordance with std. Demo/ Hermo working method what can be reused unless it is decided in consultation and the customer agrees that this will all be determined on the job.
When sorting out and working out beforehand, use the codes that were used during disassembly.
3. Determine/consult where and by whom certain operations and activities will take place.
 - a. Working on glass, profiles and doors/frames.
 - b. Selecting and sorting materials
 - c. Cleaning materials.
4. After approved drawings drawing lists for the assembly and either have this ready or

In consultation send all the material and sort it out on location.

Execution Disassembly

When it is known that materials will be used for reassembly/ second life do the following actions.

1. Disassemble materials with care, store on trestles/ pallets and pack.
2. Bundle profiles together (keep clickers near bins and brackets near frames, etc)
3. Keep frames and doors together as sets or mark them. (in the case of dopper there were many different frame/door heights but without marking all the door carts and stiles and sills on 1 trestle mixed together.
4. Maintain summary list of type, dimensions and numbers.
5. Definitely mark the glass but possibly also profiles and keep track on the summary list.
6. Consider with Projecleider/ Factory to clean materials already on site.
(remove films, tapes etc)

Execution Reassembly

On the basis of the chosen route, place materials back.

1. Select and assemble everything on site using only a floor plan.
2. Reassemble everything on the basis of detailed drawings and lists.

Does everything come to size or does glass need to be cut to size? If so, bring a glass saw.

Remaining points

Discuss actions for the factory in advance.

- Selecting glass or sorting glass and/or profiles.
- Processing of frames / doors / profiles
- Cleaning glass / profiles
- Storing X material for X amount of time





Verwol Slimline Clearvision 100 dubbelglas



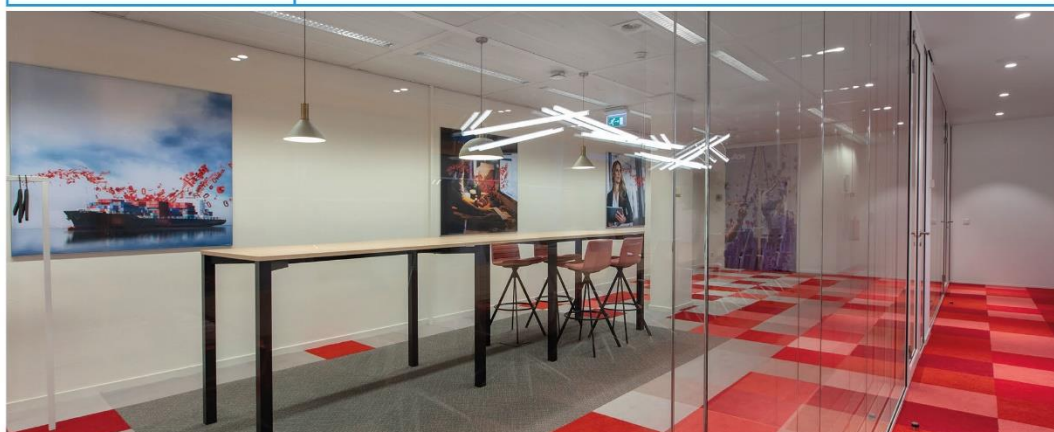
Kenmerk	Clearvision 100 module van 2.700 mm hoog en 900 mm breed
Gebouwniveau	Elementgroep 2, binnenwand – niet constructief Elementgroep 3, systeemwand
Materialen	66.A2 + 66.2 gelaagd glas-145,8 kilo- 97,38% van het totale gewicht van de module- EPD op aanvraag beschikbaar
Materialen	Aluminium- 3,1788 kilo- 2,12% van het totale gewicht van de module
Materialen	Rubber- 0,2376 kilo- 0,16% van het totale gewicht van de module
Materialen	Kunststof flushjoint- 0,2916 kilo- 0,19% van het totale gewicht van de module
Materialen	Klein materiaal: metaal en kunststof 0,216 kilo- 0,14% van het totale gewicht
Toxische stoffen	Geen, de bewijslast is de Cradle to Cradle Silver certificering
Afwerking	Aluminium gepoedercoat in Verwol RAL-kleuren
TCO	€4,88 per m2 per jaar bij 40 jaar gebruik en minimaal 1.000m2 afname

1



Verwol Slimline Clearvision 100 dubbelglas

Kenmerk	Toelichting
Producent glas	Projectmatig te bepalen
Producent systeemwand	Verwol Projectafbouw B.V.
Levering en montage	Verwol Projectafbouw B.V.
Producent aluminium	Poedercoaten door IJdema, producent aluminium projectmatig te bepalen
Losmaakbaarheid	Volledig demontabel en hermontabel zonder verlies van grondstoffen doordat er gewerkt wordt met schroef- en kliksystemen. Lijmverbindingen worden vermeden.
Levensduur	Ten minste 40 jaar
Schaduwprijs	Afhankelijk van de duurzaamheidsdoelstellingen in een project. Op aanvraag te berekenen. Door de C2C-Silver- en CO2 neutrale productiemogelijkheden zijn de schaduwkosten tot vrijwel 0 te reduceren.
Certificeringen en testen	Leverbaar in C2C Silver uitvoering
	Maximale bijdrage aan BREEAM-certificering: 31 punten > documentatie op aanvraag beschikbaar
	Ecovadis level Silver
	CO2 neutrale productie mogelijk
	Onderdeel van het Verwol Returnity programma: - Nieuw met terugkoopgarantie - Second life; product is gebruikt maar kwalitatief als nieuw meer info: www.verwol.nl/returnity
	Rw=49dB, getest door Peutz- rapportnummer A3080-329

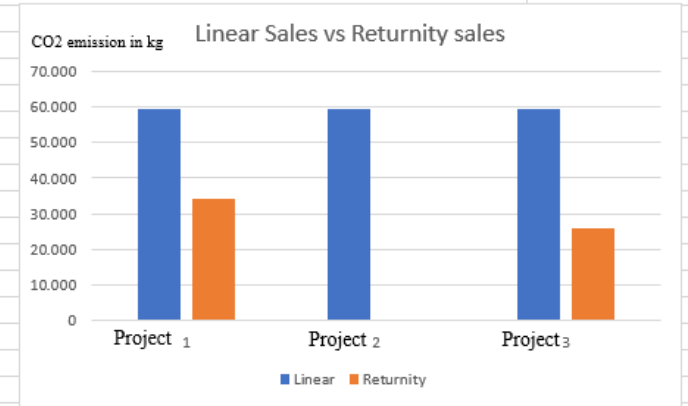


2

Appendix C Calculation 1: CO2 emissions Linear vs Circular

CO2 emissions production aluminum in CV 100	m2 cv100 element (2,7m * 0,9m)	Material per element CV100 in kg	material in kg per m2 cv100	source	CO2-emission in kg per kg material	CO2 emission in kg per m2 CV	CO2 emission in project 500m2
production aluminum CV 100	2,43	3,1788	1,308148148	Material pasport (see appendix), EPD aluminum (see appendix)	7,875	10,302	5.151
CO2 emissions production glass in CV100	kg CO2 per m2 glass (double glazed)	m2 glas per m2 CV100	source	CO2 emission in project 500m2			
Production glass	57,6	1	EPD AGC glass	28.800			
Transport	CO2 emission per km	Number of kilometers	Explanation	Source	CO2 emission project Utrecht in kg		
Logistics with medium-sized truck	0,758	200		https://www.milieubarometer.nl/co2-footprints/co2-footprint/velopa-bv-2015/ and google maps	151,6		
Van with workers	0,323	200	3,23 kg pet liter is 0,323 kg per km	https://www.milieubarometer.nl/co2-footprints/co2-footprint/velopa-bv-2015/ and google maps	64,6		
Recycling aluminum CO2 emission per kg	KG aluminum in project	explanation	Source	CO2 emission recycling			
2,91	654,0740741	500m2 * 1,3081 (kg alu per m2 CV100)	file:///C:/Users/jort.ileman/Downloads/Master%20thesis%20H.J.P.%20Claassens%20Final!.pdf	1903,355556			
Recycling glass CO2 emission per kg	KG glass in project	explanation	Source	CO2 emission recycling			
0,8	29395,16129	145,8 kg (weight of the glass in a cv100 module)/ 2,48m2 (seize of a cv100 module)*500m2 in project	Material passport and https://www.newscientist.com/article/mg23531352-000-throwaway-culture-the-truth-about-recycling/?cmpid=EMP%7CNSNS%7C2017-2307-GLOBAL-JulyWk4_Recycling%7Crecycling&utm_medium=EMP&utm_source=NSNS&utm_campaign=JulyWk4_Recycling&utm_content=recycling&cmpid	23516,12903			

Project 1 linear	Total in kg linear	Total in kg circular	
CO2 Emission production	33.951	33.951	
CO2Emission transport	216	216	
CO2 Emission Recycling	25.419	0	
Total	59,587	34.167	
Project 2 linear	Total in kg linear	Total in kg circular	Explenation
CO2 Emission production	33.951	0	
CO2Emission transport	216	432	Incl. reverse logistics
CO2 Emission Recycling	25.419	0	
Total	59,587	432	
Project 3 linear	Total in kg linear	Total in kg circular	Explenation
CO2 Emission production	33.951	0	
CO2Emission transport	216	432	Incl. reverse logistics
CO2 Emission Recycling	25.419	25.419	
Total	59,587	25.852	
Total in 3 projects	Total in kg linear	Total in kg circular	
	178.760	60.451	



Appendix D: Profit linear sales vs Returnity sales

Net prof. Linear sales vs returnity sales	Amount of	Turnover	Material cost	Labour cost	Equipment	Storage	Overhead	gross profit
Project 1 linear	500	€ 100.548	€ 42.936	€ 27.769	€ 1.463	€ 0	€ 18.627	€ 9.753
Project 1 Returnity	500	€ 100.548	€ 42.936	€ 27.769	€ 1.463	€ 5.000	€ 18.627	€ 4.753
Project 2 linear	500	€ 100.548	€ 42.936	€ 27.769	€ 1.463		€ 18.627	€ 9.753
Project 2 Returnity	500	€ 80.438	€ 0	€ 29.157	€ 1.463		€ 18.627	€ 31.191
Project 3 linear	500	€ 100.548	€ 42.936	€ 27.769	€ 1.463	€ 0	€ 18.627	€ 9.753
Project 3 Returnity	500	€ 70.384	€ 0	€ 29.157	€ 1.463	€ 0	€ 18.627	€ 21.136
Total profit linear projects								€ 29.259
Total profit Returnity								€ 57.080

Appendix E: Profit linear sales vs Returnity lease

Net prof. Linear sales vs lease with services		Amount of m2	Basis turnover	Material cost	Labour cost	Equipment	Storage	Overhead	gross profit
Project 1 linear		500	€ 100.548	€ 42.936	€ 27.769	€ 1.463		€ 18.627	€ 9.753
Project 1 Returnity lease		500	€ 100.548	42.936	27.769	€ 1.463	€ 5.000	€ 18.627	€ 4.753
Project 2 linear		500	€ 100.548	€ 42.936	€ 27.769	€ 1.463		€ 18.627	€ 9.753
Project 2 Returnity lease		500	€ 80.438	0	29.157	€ 1.463	€ 5.000	€ 18.627	€ 31.191
Project 3 linear		500	€ 100.548	€ 42.936	€ 27.769	€ 1.463	€ 0	€ 18.627	€ 9.753
Project 3 Returnity lease		500	€ 70.384	€ 0	€ 29.157	€ 1.463	€ 0	€ 18.627	€ 21.136
services per year	financing cost 6,5%	yearly lease cost*	total lease contract	total cost price leasing=	total gross profit**				
1000	€ 6.536	€ 16.298	€ 162.977	€ 112.331	€ 50.646				
1000	€ 5.228	€ 13.238	€ 132.381	€ 69.476	€ 62.905				
1000	€ 4.575	€ 11.708	€ 117.084	€ 63.822	€ 53.261				

*10 year contract, cost recoverd in 7 years

**regular profit + revenu in year 8, 9 and 10, minus financing cost minus storage cost

Appendix F: Full answers interviewees including explanatory notes

Marjon Vermeulen

	M. Vermeulen	note
1. To what extent do you consider our products suitable for reuse	4	
2. To what extent do you think we have the product stewardship to reuse the products?	4	
3. To what extent are we capable to return / relocate our products?	4	
4. To what extent are we capable to refurbish / repair our products?	5	
5. a. To what extent are we capable to add services like maintenance?	5	
b. quick repair services	4	
c. Disassembling and / or reassembling	5	
d. other service ideas?	-	
6. To what extent do you think services will be valuable for a client?	5	
7. To what extent do you think services will be valuable for Verwol?	5	
8. To what extent do you think these services extend the life of the products and thus contribute to environmental goals?	4	
9. To what extent do you consider the Returnity program financially viable?	5	
10. To what extent do you consider the Returnity program necessary for the environment?	5	
11. If it were entirely up to you, to what extent would you commit as a company to the Returnity program?	5	
12. To what extent do you think our corporate culture facilitates the implementation of the Returnity program? 5 means: the corporate culture is an enabling factor in the implementation. 1 means: the culture delays the implementation .	3	there is not enough awareness at this moment but it's improvable

13. To what extent do you personally experience positiveness or resistance to the introduction of the program? 5 is very positive so no resistance	5	
a. What does the resistance have to do with?	-	
14. To what extent do you think the group of Verwol employees is capable to make a success of the Returnity program?	3	
15. To what extent do you think there are enough tools to implement the program?	5	
16. To what extent do you think you are sufficiently informed about the program?	5	
17. Other comments about the program or the implementation of it?	-	

Pim Obdeijn

	P. Obdeijn	note
1. To what extent do you consider our products suitable for reuse	4	
2. To what extent do you think we have the product stewardship to reuse the products?	4	Depends on the situation, and the materials.
3. To what extent are we capable to return / relocate our products?	2	2. Disassembling is no problem. Handling is inefficient but not problematic. The logistic procedures will cause problems and I am not sure the current logistic department employees are capable to change Logistics however are not ready and I am not sure the current employees are capable to change towards a reverse logistics model.
4. To what extent are we capable to refurbish / repair our products?	4	
5. a. To what extent are we capable to add services like maintenance?	5	Only the doors are suitable for maintenance. In praktijk lastig door gebrek aan contact met eindgebruiker. Type product niet geschikt voor onderhoud.
b. quick repair services	3	We don't work directly for the end-user. If they find us, we can add this service.
c. Disassembling and / or reassembling	5	
d. other service ideas?		Service on hinges and door hardware
6. To what extent do you think services will be valuable for a client?	4	

7. To what extent do you think services will be valuable for Verwol?	4	Especially the doors
8. To what extent do you think these services extend the life of the products and thus contribute to environmental goals?	4	
9. To what extent do you consider the Returnity program financially viable?	3	4,5 for the small projects, 1 for the large projects
10. To what extent do you consider the Returnity program necessary for the environment?	5	
11. If it were entirely up to you, to what extent would you commit as a company to the Returnity program?	3	I would start doing more market research first before deciding
12. To what extent do you think our corporate culture facilitates the implementation of the Returnity program? 5 means: the corporate culture is an enabling factor in the implementation. 1 means: the culture delays the implementation.	1	The culture is slopping down the progress strongly.
13. To what extent do you personally experience positiveness or resistance to the introduction of the program? 5 is very positive so no resistance	4	I don't know the market potential
a. What does the resistance have to do with?		
14. To what extent do you think the group of Verwol employees is capable to make a success of the Returnity program?	4	Only logistics is a problem
15. To what extent do you think there are enough tools to implement the program?	2	
16. To what extent do you think you are sufficiently informed about the program?	2	Start good, introduction oke, after that no communication anymore
17. Other comments about the program or the implementation of it?		

Marcus Schook

		explanatory note
1. To what extent do you consider our products suitable for reuse	5	Our products can be assembled, disassembled and re-assembled.
2. To what extent do you think we have the product stewardship to reuse the products?	2	2. How to remove foils, how to transfer to the factory, how to clean, all items that are not under control now. The more we do, the better it will work.

3. To what extent are we capable to return / relocate our products?	4	
4. To what extent are we capable to refurbish / repair our products?	5	
5. a. To what extent are we capable to add services like maintenance?	5	5. We are capable to provide services but don't do it yet because of a lack of focus. It could be economically and environment-tally profitable.
b. quick repair services	4	4. Improvement can be: a quicker administration process.
c. Disassembling and / or reassembling	5	
d. other service ideas?		SLA. In-house. Refurbishment service with customized artwork
6. To what extent do you think services will be valuable for a client?	5	
7. To what extent do you think services will be valuable for Verwol?	5	
8. To what extent do you think these services extend the life of the products and thus contribute to environmental goals?	4	4. The regular 10 years user period can be extended to 30 years.
9. To what extent do you consider the Returnity program financially viable?	3	3. At this moment it's not valuable. Doing it more will improve the profitability.
10. To what extent do you consider the Returnity program necessary for the environment?	5	5. Eigen motivatie en overtuiging heb ik nog niet.
11. If it were entirely up to you, to what extent would you commit as a company to the Returnity program?	5	5. Echt mining. Echt returnity.
12. To what extent do you think our corporate culture facilitates the implementation of the Returnity program? 5 means: the corporate culture is an enabling factor in the implementation. 1 means: the culture delays the implementation.	1	1. There is not enough commitment at the management level for change in general and sustainability specific.
13. To what extent do you personally experience positiveness or resistance to the introduction of the program? 5 is very positive so no resistance	5	In involved in operations, not in sales. I could push the account managers more but the concept is not embedded enough in the organization to do so.
a. What does the resistance have to do with?		Organization goals.
14. To what extent do you think the group of Verwol employees is capable to make a success of the Returnity program?	4	
15. To what extent do you think there are enough tools to implement the program?	2	

16. To what extent do you think you are sufficiently informed about the program?	1	
17. Other comments about the program or the implementation of it?		Reducing the ecological footprint should be inspiring. It does so yet inet. It is still seen as a sales truck. That's a shame.

Niels Bakker

	Niels Bakker	explanatory note
1. To what extent do you consider our products suitable for reuse	5	We already disassemble and reassemble. No wear of the products
2. To what extent do you think we have the product stewardship to reuse the products?	4	The workers have the stewardship, not the engineers
3. To what extent are we capable to return / relocate our products?	4	
4. To what extent are we capable to refurbish / repair our products?	3	It's not yet embedded in the organisation. The potential is a 5
5. a. To what extent are we capable to add services like maintenance?	5	There must be a standard service level agreement (SLA) with fixed prices
b. quick repair services	4	
c. Disassembling and / or reassembling	4	
d. other service ideas?		Design support service.
6. To what extent do you think services will be valuable for a client?	4	4 but only for the major clients. The more meters, the more maintenance and the more it will be interesting for the cleint and Verwol
7. To what extent do you think services will be valuable for Verwol?	4	Very valuable because client loyalty will increase. To get a 5 we must have sla's
8. To what extent do you think these services extend the life of the products and thus contribute to environmental goals?	4	
9. To what extent do you consider the Returnity program financially viable?	5	
10. To what extent do you consider the Returnity program necessary for the environment?	4	
11. If it were entirely up to you, to what extent would you commit as a company to the Returnity program?	4	

12. To what extent do you think our corporate culture facilitates the implementation of the Returnity program? 5 means: the corporate culture is an enabling factor in the implementation. 1 means: the culture delays the implementation .	2	we have an ambivalent director and the project leaders are not yet on board
13. To what extent do you personally experience positiveness or resistance to the introduction of the program? 5 is very positive so no resistance	3	there is not enough back up from the management
a. What does the resistance have to do with?		
14. To what extent do you think the group of Verwol employees is capable to make a success of the Returnity program?	4	We need to change but are capable to do
15. To what extent do you think there are enough tools to implement the program?	2	
16. To what extent do you think you are sufficiently informed about the program?	4	
17. Other comments about the program or the implementation of it?		We needed a better implementation plan and back up from the board

Johan Borg

1. To what extent do you consider our products suitable for reuse	4	The custom made solutions and accessories are not suitable for reuse
2. To what extent do you think we have the product stewardship to reuse the products?	3	the limitation is the thickness of the glass (the thicker the harder) is a limitation. Shortening less than 5 centimeters is not possible.
3. To what extent are we capable to return / relocate our products?	1	We are not used to do this. If we have to bring it back to the factory than we have lack of space. If the space is there then we can do it but products must be registered and packaged on site, not in the factory.
4. To what extent are we capable to refurbish / repair our products?	1	Some items can be refurbished like door hardware but you can't change the colors. Recoloring will cause problems because the measurements of the profiles will change.
5. a. To what extent are we capable to add services like maintenance?	4	It should have been operational already
b. quick repair services	1	Our lead times are too long
c. Disassembling and / or reassembling	4	We are doing this for many years already
d. other service ideas?	Starting up a service team	

6. To what extent do you think services will be valuable for a client?	4	
7. To what extent do you think services will be valuable for Verwol?	4	
8. To what extent do you think these services extend the life of the products and thus contribute to environmental goals?	1	The products will last for at least 50 years, no matter what
9. To what extent do you consider the Returnity program financially viable?	1	Producing new is more viable for us because of the low material prices.
10. To what extent do you consider the Returnity program necessary for the environment?	1	It is not my cup of tea
11. If it were entirely up to you, to what extent would you commit as a company to the Returnity program?	1	
12. To what extent do you think our corporate culture facilitates the implementation of the Returnity program? 5 means: the corporate culture is an enabling factor in the implementation. 1 means: the culture delays the implementation .	1	Dopper werd als oud vuil hier neergegoid. Irritant. We doen maar wat
13. To what extent do you personally experience positiveness or resistance to the introduction of the program? 5 is very positive so no resistance	2	
a. What does the resistance have to do with?		We need to have a vision and a work flow process
14. To what extent do you think the group of Verwol employees is capable to make a success of the Returnity program?	1	
15. To what extent do you think there are enough tools to implement the program?	1	
16. To what extent do you think you are sufficiently informed about the program?	1	
17. Other comments about the program or the implementation of it?	At some point we have to work circular but if it is up to me, I will wait as long as possible.	

Alex Top

		explanatory note
1. To what extent do you consider our products suitable for reuse	4	We can handle differences in height up to a certain point but competitors a better capable to to this due to different systems.

2. To what extent do you think we have the product stewardship to reuse the products?	5	
3. To what extent are we capable to return / relocate our products?	3	At this moment we are not organized for it. We have the potential to reach a 5.
4. To what extent are we capable to refurbish / repair our products?	3	Depends very much on the product and the type of refurbishment
5. a. To what extent are we capable to add services like maintenance?	4	We are capable to provide services but I don't think it is profitable
b. quick repair services	4	We can conduct quick repair services but we differentiate in the clients. For the important clients we act fast and some clients we ignore.
c. Disassembling and / or reassembling	5	That's what we do on a daily basis
d. other service ideas?		
6. To what extent do you think services will be valuable for a client?	5	
7. To what extent do you think services will be valuable for Verwol?	3	Depends on the type of client
8. To what extent do you think these services extend the life of the products and thus contribute to environmental goals?	2	Only the doors.
9. To what extent do you consider the Returnity program financially viable?	4	There is market potential but new materials are cheaper than reusing
10. To what extent do you consider the Returnity program necessary for the environment?	4	
11. If it were entirely up to you, to what extent would you commit as a company to the Returnity program?	4	There is market potential
12. To what extent do you think our corporate culture facilitates the implementation of the Returnity program? 5 means: the corporate culture is an enabling factor in the implementation. 1 means: the culture delays the implementation.	2	Mensen hebben er niet zo veel zin in.

13. To what extent do you personally experience positiveness or resistance to the introduction of the program? 5 is very positive so no resistance	5	No resistance at all
a. What does the resistance have to do with?		
14. To what extent do you think the group of Verwol employees is capable to make a success of the Returnity program?	2	As long as not everybody is aligned there won't be much progress
15. To what extent do you think there are enough tools to implement the program?	4	For me it is okay but there is no work flow process
16. To what extent do you think you are sufficiently informed about the program?	4	
17. Other comments about the program or the implementation of it?		It is necessary to pay more attention to internal communication

Appendix G: Environmental Product Declaration AGC

This figure is a print screen of the full AGC environmental product declaration (EPD). The full EPD is available upon request but is too extensive to attach in this document



ENVIRONMENTAL PRODUCT DECLARATION
in accordance with ISO 14025 and EN 15804+A1

Environmental impacts of 44.2 laminated glass

Environmental impacts	Production stage	Construction process		Use stage							End of life stage				Benefits and loads beyond system boundaries
	A1-A3 Total Production	A4 Transport	A5 Installation	B1 Usage	B2 Maintenance	B3 Reparation	B4 Replacement	B4 Refurbishment	B6 Use of energy	B7 Use of water	C1 Deconstruction /demolition	C2 Transport	C3 Waste processing	C4 Disposal	D
Global warming potential (kg CO ₂ eq./FU)	2.88E+01	1.61E+00	NR	NR	6.87E-03	NR	NR	NR	NR	NR	NR	1.05E-01	NRE+00	3.74E-01	1.22E+00
Ozone depletion (kg CFC-11 eq./FU)	2.58E-08	4.38E-14	NR	NR	2.69E-09	NR	NR	NR	NR	NR	NR	2.90E-15	NRE+00	8.71E-14	1.52E-09
Acidification of land and water (kg SO ₂ eq./FU)	1.09E-01	3.90E-03	NR	NR	2.32E-04	NR	NR	NR	NR	NR	NR	6.20E-04	NRE+00	2.02E-03	2.30E-03
Eutrophication (kg PO ₄ eq./FU)	1.60E-02	9.45E-04	NR	NR	1.65E-04	NR	NR	NR	NR	NR	NR	1.57E-04	NRE+00	4.11E-04	4.37E-04
Photochemical ozone creation (kg C ₂ H ₄ eq./FU)	7.67E-03	3.89E-04	NR	NR	9.54E-05	NR	NR	NR	NR	NR	NR	4.90E-05	NRE+00	1.63E-04	1.77E-04
Depletion of abiotic resources-elements (kg Sb eq./FU)	2.36E-05	1.20E-07	NR	NR	1.77E-07	NR	NR	NR	NR	NR	NR	7.94E-09	NRE+00	4.98E-08	1.27E-07
Depletion of abiotic resources-fossil fuels (MJ/FU)	4.03E+02	2.18E+01	NR	NR	3.88E-01	NR	NR	NR	NR	NR	NR	1.45E+00	NRE+00	4.92E+00	1.20E+01